Richard Wies & Marc Mueller-Stoffels

Wind-Diesel Applications Center Test Facility (Hybrid Applications Lab)

WiDAC Team Members

- WiDAC Lead
  - Marc Mueller-Stoffels
- WiDAC Technical Liaison
  - Daisy Huang
- WiDAC Outreach Liaison
  - Julie Estey
- Other team members
  - Project dependent: research engineers, staff

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Energy Technology Lab (ETL) Team

- ETL Manager
  - Brent Sheets
- ETL Engineering Lead
  - David Light (Decades of Experience)
- Research Engineers
  - HVDC
  - Controls
  - Heat Recovery
  - Batteries
  - Advanced Modeling

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Hybrid Applications Test Bed

- 1:1 model of rural Alaskan power plant
- Immediate Purpose:
  - High contribution wind power research
  - Diesel-off mode research
  - Enable new technologies – Development Partnerships
  - Performance testing
  - Integration studies
  - Training

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Applicability for Rural Alaska

- Displace/reduce use of diesel fuel
- Reduce cost of power
- Increase sustainability
- Create opportunity

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Wind-Diesel Test Bed Assets/Status

- 300 kWe Caterpillar (*operational*)
- 125 kWe Detroit (*to be overhauled*)
- 100 kWe Wind-Turbine Simulator (*operational*)
- 1000 Ah @ 336 VDC Lead-Acid Battery (*operational*)
- 250 kW 208 VAC Load Bank (*operational*)
- 250 kW 480 VAC Load Bank (*in production*)
- Generic Control and Data Acquisition Circuits (*to be completed*)
- Grid Forming Inverter

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Assets – Diesel Gensets

- 300 kWe Caterpillar
- 125 kWe Detroit
- Woodward EasyGen Controls
  - Very high level of control
- Building heat recovery loop

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Assets – Wind Turbine Simulator

- 100 kWe Motor-Generator
- Wind speed input
- Can model various turbines
- 50 – 100 kW typical turbine size for rural AK

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Assets – Battery & Load Banks

- Sealed Lead-Acid
- 1000 Ah @ 336 VDC
  - 150 kWh (DC) usable
  - 160 kW max Power
- Two variable load banks
  - 250 kW 208 VAC
  - 250 kW 480 VAC
  - $\Delta P = 5$ kW; $\Delta Q = 10$ kVARs
  - PF = [0.8, 1] at max load

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Assets – Grid Forming Inverter

- 200 kVA DC/AC bi-directional IGBT inverter
- Uses battery
- Frequency and VAR support
- High contribution of wind
- Diesel-off mode

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Energy Systems Integration

- Major needs identified
  - Optimization: Evaluate centralized vs. distributed control
  - Need highly distributed generation circuit model
  - How large can the grid be without rotating equipment?
  - How can we best integrate new technology with existing infrastructure?

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WiDAC Current Projects

- Research and Development
  - Independent Data Acquisition, *ongoing*
  - Grid-Forming Inverter, *ongoing*
  - Control Systems, *ongoing*
  - Advanced Modeling, *ongoing*
  - Energy Storage, *planned*
  - Wind-Diesel Systems Re-Analysis, *planned*
  - Best Practices Guide, *planned*
  - Identify Cold Region Small Turbine Test Site

Data Collection and SCADA

- Flexible integration of Control Schemes
- General interface hardware built
- General, robust data collection in development
- Currently, build/test ABB distributed control system
- Setup for hardware-in-the-loop hybrid models
- Development and testing of data collection equipment for remote locations (BlackBox)

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First Project – Grid Forming Inverter

Funded by the Denali Commission, Partnership with Marsh Creek LLC

- Project Benefits:
  - Enabled full power level development
  - Testing informed further development
  - Basis for informed decision by stakeholder
- Project Results:
  - Diesel-off mode partially confirmed: *requires sync. condenser (spinning mass)*
  - Grid support mode confirmed
  - Final report pending

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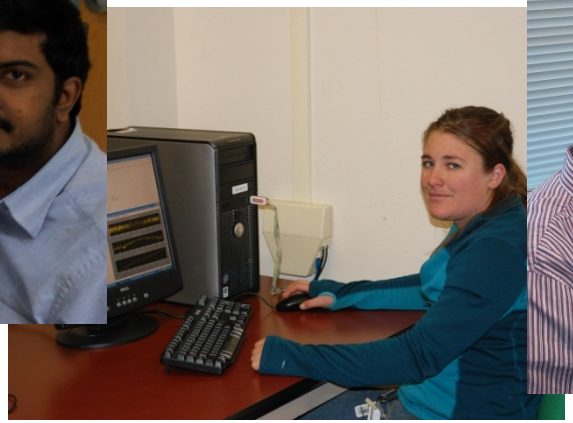
Advanced Modeling Research

- 3 Graduate Projects under DOE EPSCoR
  - Eshwar Chukkapalli, MS EE with Rich Wies
  - Maura Sateriale, MS ME with Rich Wies
  - Nick Janssen, PhD with Rorik Petersen



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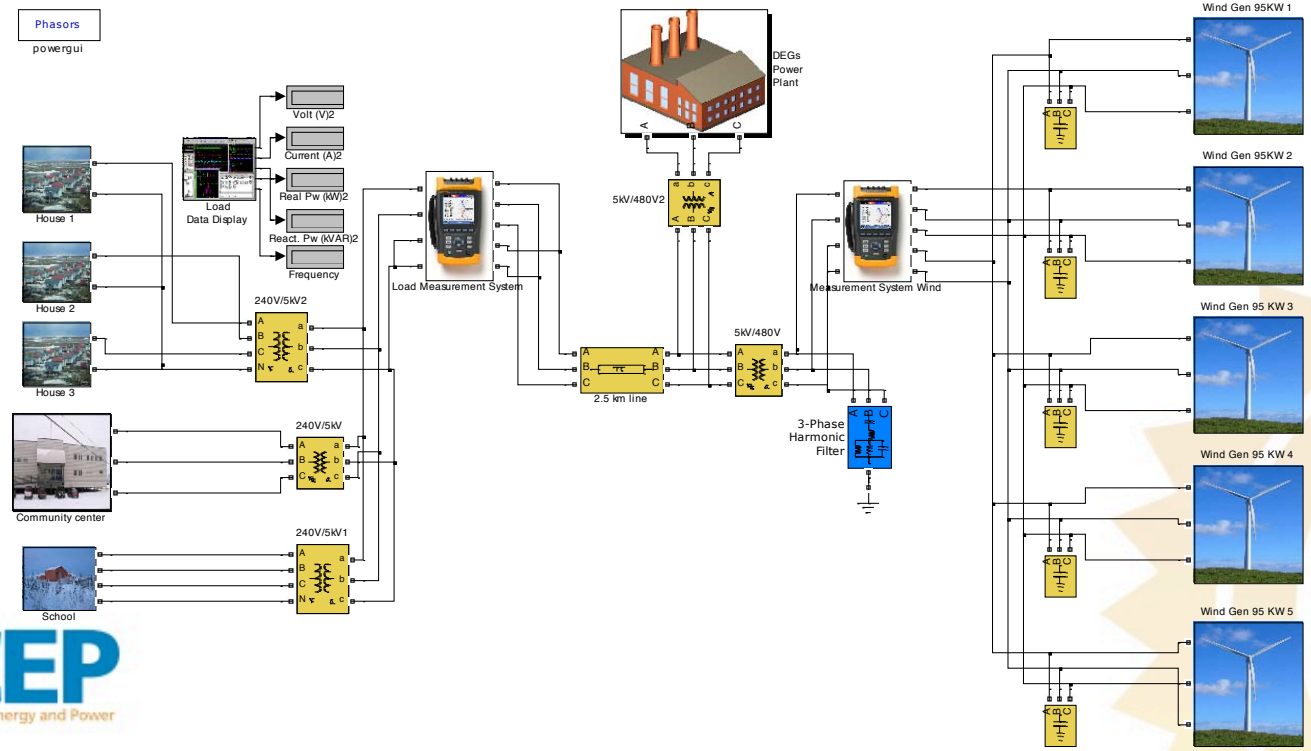
Dynamic Wind-Diesel Generation Management Model, Eshwar Chukkapalli

- Objectives
  - Economic Dispatch of Wind & Diesel
  - Control & Stability with Dynamic Wind Resource



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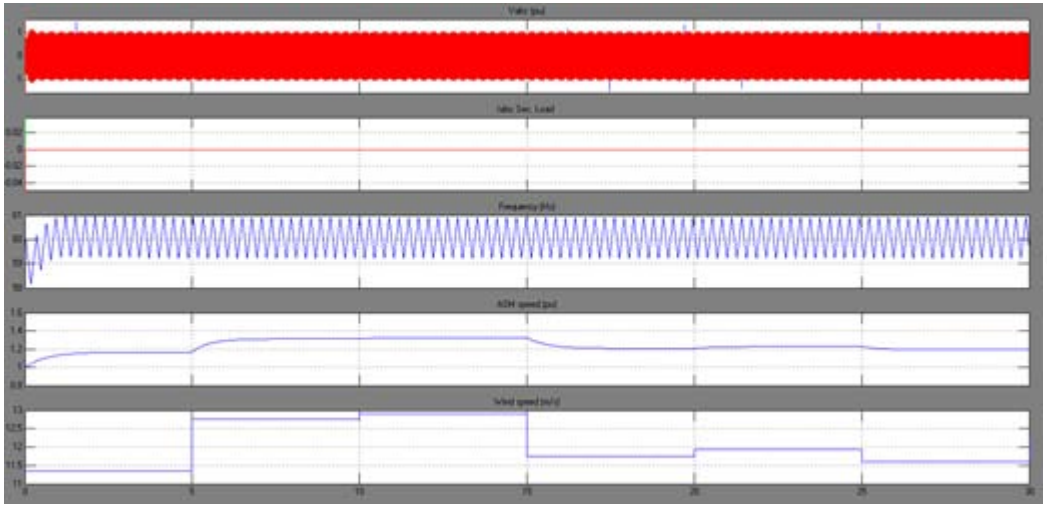
Dynamic Wind-Diesel Generation Management Model, Eshwar Chukkapalli



505 kW Load, 150 kW Wind Standard Control Scheme Note: Voltage Ripple and Frequency Oscillation

505 kW Load, 150 kW Wind, GA Diesel Control Note: Voltage and Frequency Stabilize

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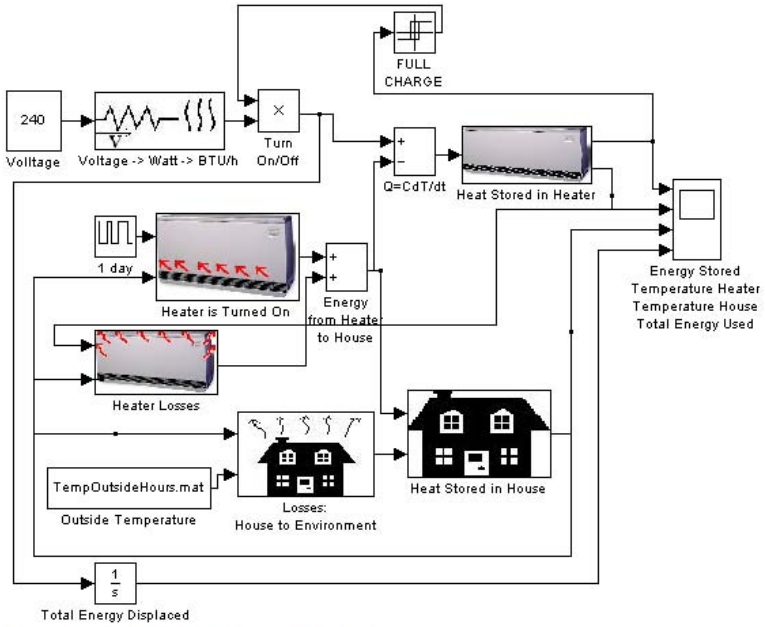
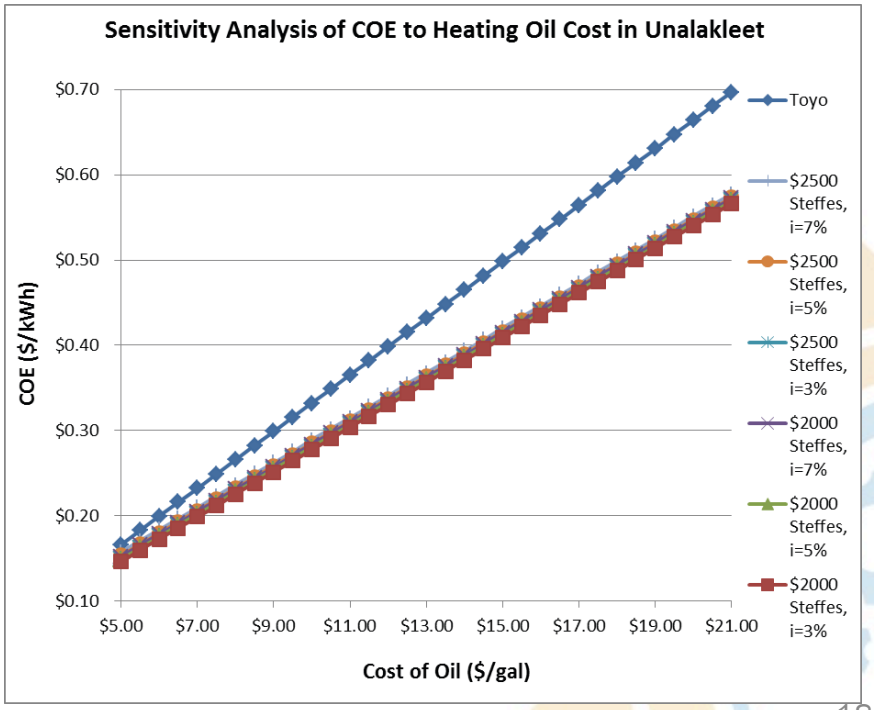
Electrothermal Heat/Storage Model,

Maura Sateriale

- Objectives
  - Electric Power from Wind to Displace Oil Heating
  - Thermal Storage as Diversion Load





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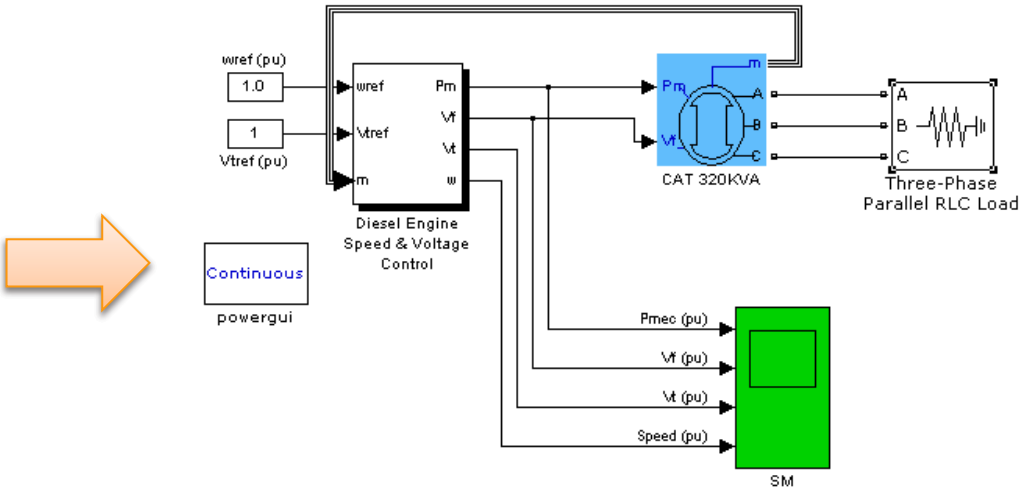
ETL Component Model, Nick Janssen

- Objective
  - Reduce project cost on equipment testing
  - Groundwork for Hardware-In-The-Loop testing



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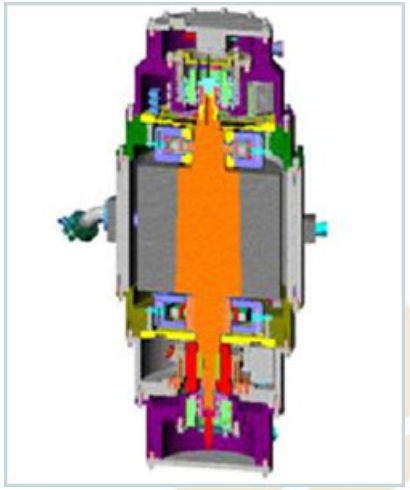
Path Forward

- Near-term:
  - Electrothermal storage (funded)
    - Test dispatch strategies
    - Self-regulated grid control
  - Fuel additive study (funded)
  - Fly-wheel integration and testing study (funding pending)
  - Expand SCADA, metering, and equipment



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Path Forward

- Long-term:
  - Heat recovery system
  - Include PV simulator
    - Wind-PV-Diesel interaction
    - Improve Diesel-off capabilities
  - Training facility
    - Wind-diesel system certificate
    - Renewable Energy Systems Degree

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